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INDUSTRIALISATION OF COCONUT PRODUCTS AND BY-PRODUCTS

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INDUSTRIALIZATION OF COCONUT PRODUCTS AND BY-PRODUCTS

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Introduction

1. The coconut is the premier income-producing export crop in the Philippines. With an annual harvest of eight billion nuts (about 9 million tons) and a production during calendar year 1961 of 694,295 long tons of copra valued at $99,043,840 and 72,400 long tons of copra oil valued at $15,310,345, the Philippine is the world's biggest nut and copra producer. Other principal coco products exported in 1961 are copra cake-meal valued at $3,493,256 and dessicated coconut valued at $14,351,060. As such, the coconut industry, upon which about 1/3 of the Philippine population (around 9 million) depend wholly or partly for their livelihood, is the backbone of the nation's economy. 1/

2. However, the status of the industry, even with its present contribution to the country's economy as the above data indicate, is not stable, its future uncertain because of two factors: the threat of "cadang-cadang" disease of coconut trees and the increasing competition from synthetic detergents in foreign markets. The income derived from the industry represents only a small portion, about 20% of the total amount that can actually be obtained if all parts of the fresh matured nut is completely utilized and industrially developed into various higher-priced consumer commodities, considering that at present crudely-processed, low quality copra and poor quality copra oil are only the main produce. Only 20% of the whole nut is now being utilized, 80% go to waste.

3. The coconut therefore ranks foremost in potentialities for industrialization. It is in this area where the top-priority application of science and technology has been considered by the National Institute of Science and Technology (NIST)

1/ Data cited taken from 1961 Annual Report of the Philippine Coconut Administration and other statistical records of the same office.

as the most promising in terms of results that will tremendously enhance Philippine socio-economic progress.

The Five-Year Coconut Industrialization Program

4. The NIST, formerly the Bureau of Science, was reorganized, its functions and facilities expanded in July 1958 by the Philippine Science Act of 1958 and has been charged with undertaking research and development activities in the conventional sciences, particularly in fields selected as to their impact to the national economy and to their relation to the needs of existing and/or possible future industries. Being a developing country the direction and application of science and technology to our research and development efforts require that priority consideration is given to the exploitation of our more abundant native raw materials to increase exports and reduce imports and generate more job opportunities for our rural population.

5. The NIST, in accordance with the criteria of its governing National Science Development Board for program/area priorities of food, clothing, shelter and medicinals, and its own criteria for priority rating of specific research and development projects has, among its several areas of research, given top-priority to the industrialization of coconut products and by-products. In the formulation of this program, it was deemed of economic necessity that the coconut industry should be diversified and oriented towards new directions of development and growth. The economic value of the coconut can be greatly increased by developing the vast food product potential of the coconut industry and gradually eliminating primitive copra making.

6. The NIST 5-year research program (1961-1966) for the coconut consists of two complimentary and simultaneous phases, the laboratory research phase and the pilot plant development phase. Under the first phase, inter-related research problems selected after thorough literature survey and project evaluation are being undertaken with the object of finding new, technologically and economically feasible process or processes of producing specific end-products, or improving and adapting already known industrial process or processes to suit local materials and conditions. Experimental projects completed in the laboratory are tried or tested under pilot plant conditions to obtain more reliable technico-economic data as bases for commercial scale production.

7. The primary objective of the program is the development of an optimum integrated process for the complete utilization of the components of the coconut including husk and the design and construction of a continuous coconut by-products processing plant utilizing fresh matured nut as the raw material.

8. Coordinated work operations on selected projects under this program being undertaken by the Institute's Industrial Research Center have been divided/

distributed to several teams of coconut researchers based on specific raw material to be used and end-product objectives, to wit; (a) projects centered on the husk; (b) projects centered on the shell; (c) projects centered on the meat and oil; and (d) projects centered on the coco water.

Research Projects Centered on the Husk

9. The components of the husk that could be industrially utilized are (a) the long (bristle) fibers - 10%; (b) the short (mattress) fibers - 25%; and (c) the coir dusts - 65%. A very insignificant portion of the total husks output of copra making is being utilized in the small local home industry level for the manufacture of ropes, twines, doormats, brushes, floor carpets and cushion materials for upholstery products. Almost 90% of husk raw materials are thrown away as waste in coconut growing provinces.

10. The objective of the NIST project on the coco husk is the development of an optimum processing method of converting husks into marketable products, particularly for pulp and thermal insulating materials. The end-product objective of another research project is the utilization of the short fibers and coir dusts for the manufacture of hard boards. A related ongoing project is the extraction of the lignin content of the husk and a subsequent study on its commercial value. A microbiological method of retting coco husks in order to improve the spinning quality of coco fibers is also being undertaken.

11. Under the engineering aspect related to husk utilization studies are two projects: (a) fabrication from an improved design of a mechanical dehusking machine, and (b) design, development and construction of an automatic, electronic coconut maturity sorter for husked or unhusked coconuts to separate the young from the matured nuts without slowing down the flow of nuts in a conveyor belt.

Research Projects Centered on the Shell

12. Research projects on this coco component are concentrated on four marketable end-product objectives: (a) grinding the shell and, by flash carbonizing, recover the distillate as crude creosote; (b) recovering the charcoal and processing these into briquetted charcoal fuel without using binders; (c) processing the charcoal to produce carbon black or carbon electrodes, and (d) processing the shell by using an NIST-developed method to extract and produce furfural.

13. On the engineering-equipment side, developmental studies are centered on the design and fabrication of a mechanical de-shelling machine that can efficiently and rapidly remove the fresh coco shell without breaking the meat and the fabrication of a mechanical coconut paring machine for removing the brown coating of the meat.

Research Projects Centered on the Meat

14. The coconut meat is by far the most important component of the coconut and the greatest source of many commercial higher-priced by-products, especially food products required to augment the food needs of a fast-growing Philippine population which is increasing at a rate of 3.2% per annum.

15. Preliminary economic-profitability studies in the NIST have shown that more income will be derived from the meat by utilizing it as a material for various food products than when made into copra. Hence, concentration of NIST research and development work is on the meat in order to produce in marketable form "granulated coconut" as the main product by fluidized bed method.

16. Other major coco food projects are on the production of high-grade, water-white edible oil with low fatty acid (dry process), coconut sweetened condensed milk, coco breakfast food from coco flour, coco cheese, coco soft drink and coco protein.

17. Coconut oil as a source of a potent biological insecticide is also being investigated. Studies on the utilization of coconut oil soapstock by esterification of the fatty acids for the production of quarternary ammonium compounds is also underway.

18. Completed laboratory research projects being readied for pilot plant trials (development phase) are described under separate items in ensuing paragraphs.

Research Projects Centered on the Coco Water

19. Research studies on the utilization of this coconut component are centered on two major projects: (a) its uses as a medium in a microbiological process of producing (by means of a polysaccharide) a thermoplastic material that can be used for paint lacquer and plastic materials; and (b) its use for the propagation of protein-rich and Vitamin B-rich food yeast using a strain of Torulopsis utilis (Henneberg) Lodder.

Completed Laboratory Research Projects: Development Aspects

20. The new approach to the main coconut project of the NIST is the development of an integrated continuous process for the full utilization of the coconut which combines the following steps: (a) husking the coconuts; (b) shredding the husks and separating the long fibers, short fibers and the coir dusts; (c) processing the fibers and coir dusts into either pulp or for construction materials; (d) shelling the dehusked nuts; (e) grinding the shells and other husk wastes and carbonizing the mixture, recovering the creosote distillate and separately recovering

the charcoal for briquetting or for carbon electrodes or carbon black; (f) grinding the cleaned meat to micron size; (g) drying the ground meat in a fluidized bed dryer with simultaneous production of edible grade, white granulated coconut with controlled oil contents as desired for the food product end-use; (h) evaporation of the coconut water to produce a 50% coconut concentrated syrup or using it for the microbiological production of yeast or plastic materials. A patent has been filed for this process and equipment design. Most of the special components of the pilot plant equipment are being designed and fabricated in the NIST engineering shops.

21. Fluidized bed - granulated coconut: Our experiments have shown that coconut meat ground to micron size in a colloid type mill can be dried at a high speed and relatively low temperature in a fluidized bed chamber designed and fabricated in the NIST. The finely divided wet and somewhat pasty-material undergoes a granulation effect in the fluid bed at proper air velocities. Apparent air velocities above the one to two ft/sec. usually employed in a fluidized bed with fine particles are necessary. The velocities are in the liter bed rangs of four to ten ft/sec. The granulation effect eliminates fines and results in a preferred product and better operation. Present indications are that dimensionally the Fluo-Solids Dryer can be scaled down to a small size and that the temperature of the meat can be held to below 120°F, and the drying completed in a matter of minutes. Experiments indicate that dried granulated meat of good color, taste and odor can be produced. The oil pressed from this meat is of a water-white edible quality having long shelf life.

22. Creosote and charcoal briquettes from carbonization: Binders used for briquetting charcoal usually account for a substantial part of the total manufacturing cost. It has been found possible to eliminate the use of binders by combining the ground shell and husk waste and after packing this mixture into a mold under pressure, carbonizing it in a retort and recovering the creosote distillate. Proper molding pressures and carbonization conditions have been worked out to get a desirable product. The carbonizing process takes only 150 minutes at 250°C. The equipment and method of operation are relatively simple.

23. Concentrated coconut food flavor extract: Since the integrated process is directed toward diverting the coconut products into food product channels, a new quality, namely flavor, becomes highly important. The granulated coconut, since it is produced from fresh, quality coconuts at low temperature and in the shortest possible processing time, in a matter of minutes, has an excellent flavor and good keeping qualities. Development is under way to enhance the flavor when desired and to extract and eliminate the coconut odor and flavor where the bland product is preferable. Same process may be used in oil for margarine, edible oil and coco flour for some baking purposes. The extracted concentrated coconut flavor would be a high-priced product. Indications of success in this direction have been obtained through the research.

24. Sweetened coconut condensed milk: Pure "gata" or coco cream is obtained by pressing fresh grated meat. Coconut water is used for a second expression. Allow the milk from second expression to stand for one hour after which the upper layer or cream containing approximately 32% oil, 55% water, 6.57% protein and 6% carbohydrate and salt, is separated. The skimmed milk of lower layer contains approximately 1.8% protein, and the cream-skimmed milk separated from the cream by a special process of dewatering has 2.55% protein. The dewatered cream still contains about 2.3% protein. An amount of the second cream is added to the total skimmed milk to give an oil of 3.5% per cc. The mixture is vacuum distilled to a certain fraction of its original volume then 20% sugar per cc. of original milk volume is added. The process of condensation ceases when the product attains a density of 1.9. It is then placed in proper container, sealed, and pasteurized. The above product with observed long shelf life, has been analyzed to contain the following; protein 9.97%; fat 10.8%; sugar 54%; water 23.06%; ash 2.17%. The sweetened form is economically preferable, because use of sugar will also benefit the local sugar industry. This process is separated from the main integrated dry process. This food product was developed to utilize that portion of the country's total output of coconut raw materials that could not be used for the integrated fluidized bed dry process.

25. Coconut protein: The coco protein study which was first tried on experimental animals showed that the quality of coconut protein isolated from fresh mature coconuts by a process developed and employed in the NIST Food and Nutrition Research Center is comparable with casein of milk in all the essential amino acids and in promoting growth and in its percentage of body utilization. The same coconut protein when tried in formulations for infant feeding of healthy prematures showed great possibilities. Of the vegetable proteins tested, coconut protein showed better digestibility, higher biological value and a more efficient utilization of the nitrogen than cottonseed, peanut, sunflower or sesame flour. The only difference with animal protein products is that the formulation using vegetable protein has to be made at a level of 3.5 - 5.0 gm. per kg. body weight, whereas the same results can be achieved with 2.0 - 3.0 gm. per kg. of the animal protein. But the important finding in this study is the fact that coconut protein can support the normal growth of infants. Significantly, if our copra oil export volume, roughly equal to 5 1/2 billion coconuts, can be processed into 94,000 metric tons of coco protein, this big amount can greatly benefit for a whole year about 13 million protein - deficient Filipinos and other Asians, if given as a food supplement at the average intake level of 20 grams daily.2/

26. High-protein food yeast: A prolific food yeast, Torulopsis utilis (Henneberg) Lodder, rich in protein and B-vitamins can be grown in coconut

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2/ Concepcion, I., Gonzales, J. and Intengan, Carmen Ll., Preliminary Studies On the Quality of Coconut Proteins, Reprinted from the Proceedings of the Ninth Pacific Science Congress, 1957, Vol. 15 (1959)

water fortified by the addition of ammonium sulphate and trisodium phosphate, to produce a crop about ten times the original seed yeast provided that sugar concentration, aeration, pH and temperature are controlled. The sugar concentration is kept constant at slightly more than one per cent; sterile air is passed through the mash; pH is maintained at about 5.0; and the temperature of the fermenting mash is not allowed to rise more than 32°C. The yeast crop is separated by centrifuging and then dried at 40°C. The dried yeast cells contain about 50 per cent of biologically complete and palatable protein.

27. Detergents from coconut oil: Preparation of pure lauryl monoglyceride was undertaken. Lauric acid was reacted with SOC_1 and the lauryl chloride obtained. 1,2-isopropylendine-glycerol was prepared by reacting glycerine with acetone in the presence of a certain catalyst. Reaction of the lauryl chloride with the acetone-glycerol and quinoline was accomplished (after synthesis of the quinoline) and the product purified in high vacuum. Monoglyceride of 48% purity was obtained. Sulfation of the monoglyceride followed and the product neutralized. Mixture of the sulfated product with soap and binders give a fairly nice product simulating soap in texture and having washing properties comparable to commercial soaps and detergents.

Technico-Economic Interpretation and Tentative Evaluation of Results

28. Preliminary results obtained under the program indicate promising technico-economic gains. Tentative profitability estimate based on a coconut processing plant, being designed under this program, with a capacity of 100,000 nuts a day indicates a 74% return on an investment of about ₱740,000 ($370,000; conversion is ₱2 to $1).

29. The establishment of small field processing units and large central units in strategic locations in the four major coconut regions of the Philippines are contemplated to be the targets by the end of the development program. This will increase the per capita income of our rural coconut growers in line with our government's 5-year socio-economic development program. The NIST, being a government agency can not operate commercial enterprises, hence, it will transfer to private sectors the commercial scale operation of the basic plant under certain mutually agreed upon arrangements.

30. Since under present plans for the main project in which the steps of yeast production and oil extraction have been separated from the field processing unit, the equipment costs and process operations have been simplified and reduced to a point where much smaller field units than the 100,000 nut-per-day unit are possible. It fact, it now appears possible that a field unit capacity of 10,000 to 15,000 nuts/day may be economical and desirable in some locations and under certain conditions. To tie in with these smaller field units, there should be larger central processing units. The central processing unit would take the output of

products of a number of small field units and process them further when necessary for high-priced food products and for satisfying market demands and to expedite merchandising.

31. In terms of estimated economic gains to the coconut farmer, and other people involved in the industry, the diversified utilization of the fresh coconut is expected to give them a greater income than from what they are now deriving from copra. A recent survey conducted by the University of the Philippines' College of Agriculture, indicated that the average small coconut grower receives about ₱.048 per nut for his crop in the form of copra. His average crop amounts to 13,300 nuts or ₱638.40 per year. Out of this low income he pays ₱188.00 for labor and expenses, leaving him a net income of ₱450.40 per year. He is idle for 7.8 months each year. There are generally no other jobs available. 3/

32. As opposed to this existing situation, the establishment of numerous small coco field processing units, as preliminary economic studies in the NIST indicate, would raise the coco grower's income from the present ₱.048 per nut to at least ₱.07 per nut. He would also get paid for hauling the nuts to the plant. And finally there would be additional jobs in the processing plant at ₱7.00/day. Thus the grower's income would be increased two or threefold. The recovery of by-products would add another ₱23.00 per ton to the value of nuts. There being around 4,000,000 tons available per year for this type of processing, this represents a potential income of ₱92,000.00/year. The upgrading of the copra from ₱0.213 per lb. to ₱0.275 per lb. would represent an additional potential gain of ₱86,000,000/year. Setting up a central processing plant would thus create still more jobs and add greater values to the crop income by diverting the crop into higher-priced food product end-uses and further utilizing the by-products. 4/

Conclusion

33. The stability and increased income potential of the Philippine coconut industry depends to a very large degree on intensified industrial research and development work aimed at diversifying its products and by-products by complete utilization of the components of fresh nut, instead of relying on copra . To accelerate success, however, the NIST needs assistance in the form of additional up-to-date "multi-purpose" pilot plant equipment from more industrially advanced countries willing to extend help.

3/ Schuh, Charles H. Development of An Industrial Research Program in the Philippines, Quarterly Report No.3, (AID/NEC/ARF Expert Posts Project) Armor Research Foundation, Chicago and Agency for International Development, Washington, D.C. (July 2, 1962).

4/ Ibid.

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